SOLFINS

MECHANICAL ANALYSIS AND OPTIMISATION OF CABLE DRUM ASSEMBLY

FEA report

Abstract

The purpose of this calculation is to check the maximum magnets displacement on the Cable Drum Assembly. Maximum magnets displacement should not be greater than 0.3mm according to defined project and working requirements. An analysis using finite element method (FEM) was performed to optimize the Cable Drum design.

May 2010

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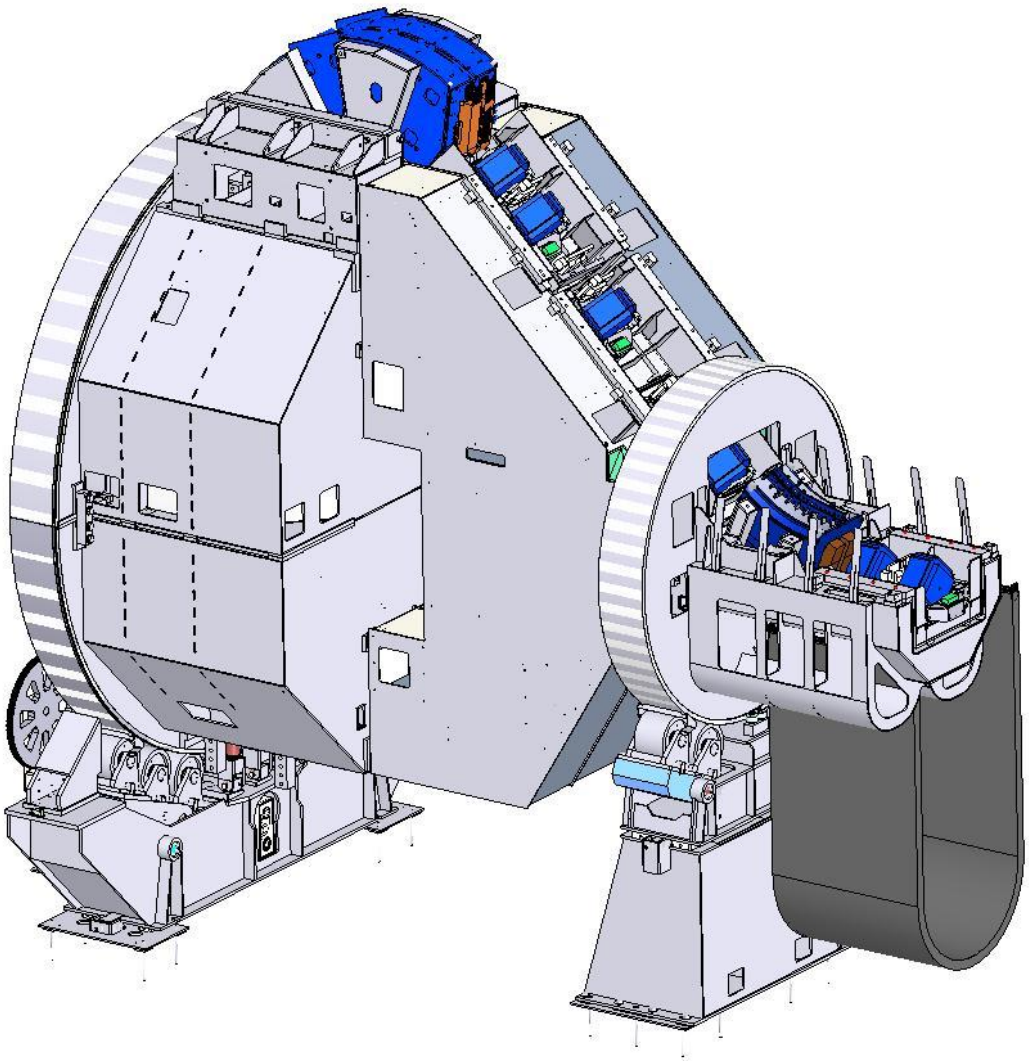
1. INTRODUCTION

The purpose of this calculation is to check the maximum magnets displacement on the Cable Drum Assembly and to strengthen the Cable Drum construction if it is necessary. Maximum magnets displacement should not be greater than 0.3mm according to defined project and working requirements.

Gantry construction is set to Front Roller Assembly from front side, and to Rear Roller Assembly from back side. Front and Rear Roller Assemblies allows rotation of the whole Gantry construction. The influence of the magnets weight it's critical to deflection of the Cable Drum Assembly. This influence is different in different Rotational positions, so the calculations should be done for several positions.



1.1. Cable Drum FEA Requirements

External leads:

- Quadropole Magnet and Brackets = 700 kg
- 45 degrees Dipole Magnet = 8t
- Weight of Weldment
- Gravity

Weight of cables and Energy Chain

- 100 pounds / foot (149kg/m)

Length of Cables and Energy Chain

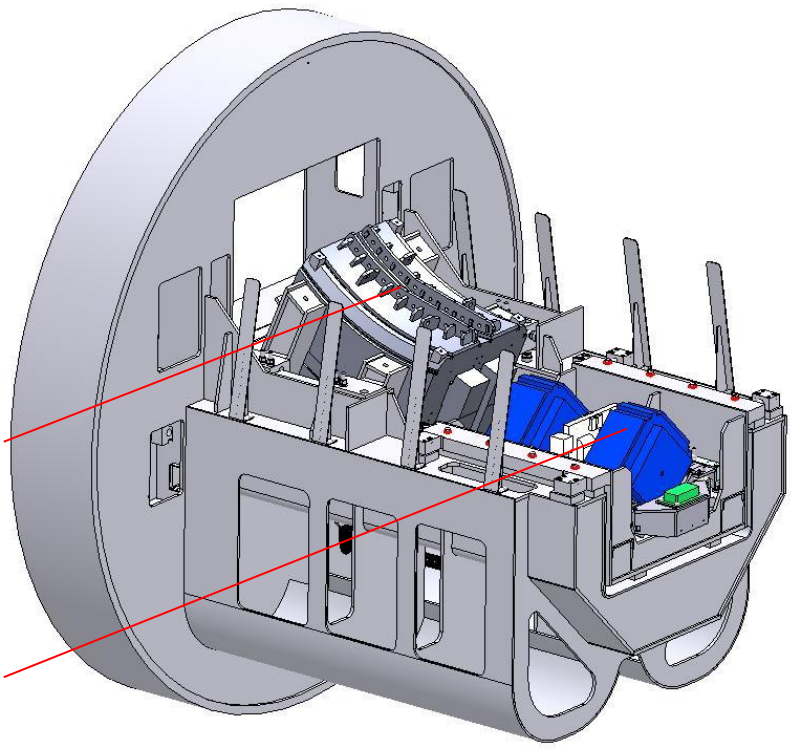
- 8425 mm

Cable Drum will be Evaluated at following Rotational Positions:

- 0 degrees
- +45 degrees
- +90 degrees
- +135 degrees
- +180 degrees
- -45 degrees
- -90 degrees
- -135 degrees

Constrains on Cable Drum

- Face where cable drum is attached to remainder of ganty
- Areas where ring makes contact to rollers



2. GEOMETRY AND MATERIAL PROPERTIES

2.1. Simplifications

The geometry of the Cable Drum and simplifications for the purpose of calculations are shown at the below picture. Touch faces between Cable Drum Assembly and Rear Roller Assembly are fixed in this study. The influence of the Gantry assembly masses are accounted as distributed masses or forces to the touch faces between Cable Drum and MGirder-MAG Assembly.

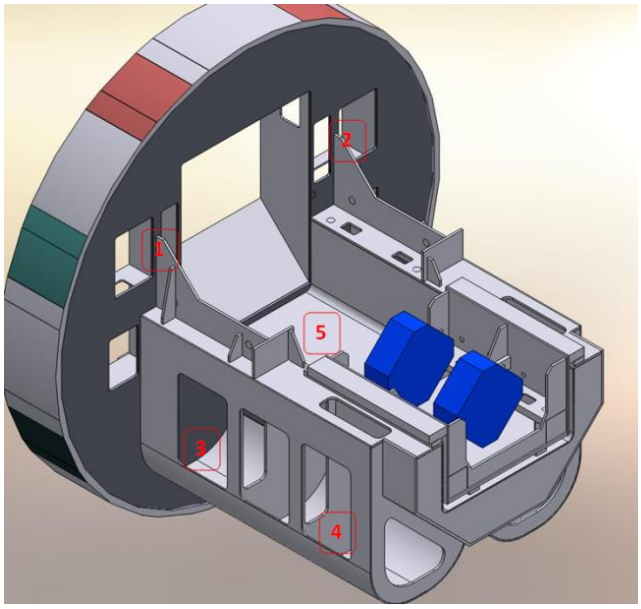
The brackets for magnets are removed for simplification purposes and are represented as rigid bars connected at split faces that are made from contact surfaces of removed brackets. The magnet assemblies with brackets are checked in separate studies and according to given results we can consider brackets in calculations as rigid bars.

Small features and parts that are not caring load are removed for clarity and to reduce computational requirements.

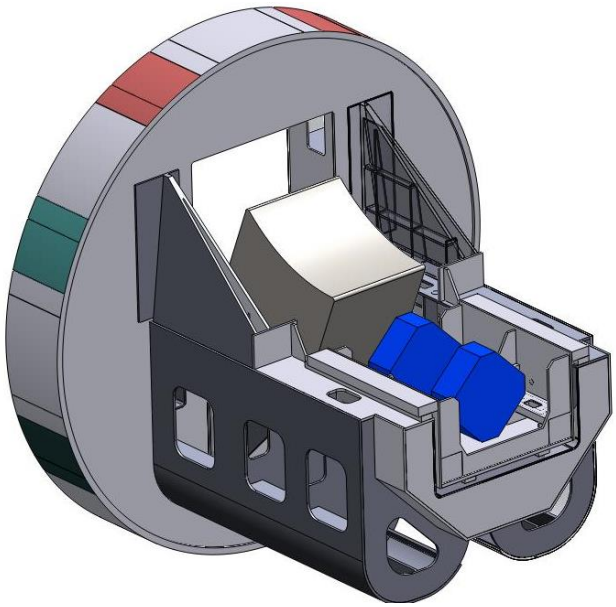
Missing components are accounted as distributed masses or forces.

2.2. Design changes

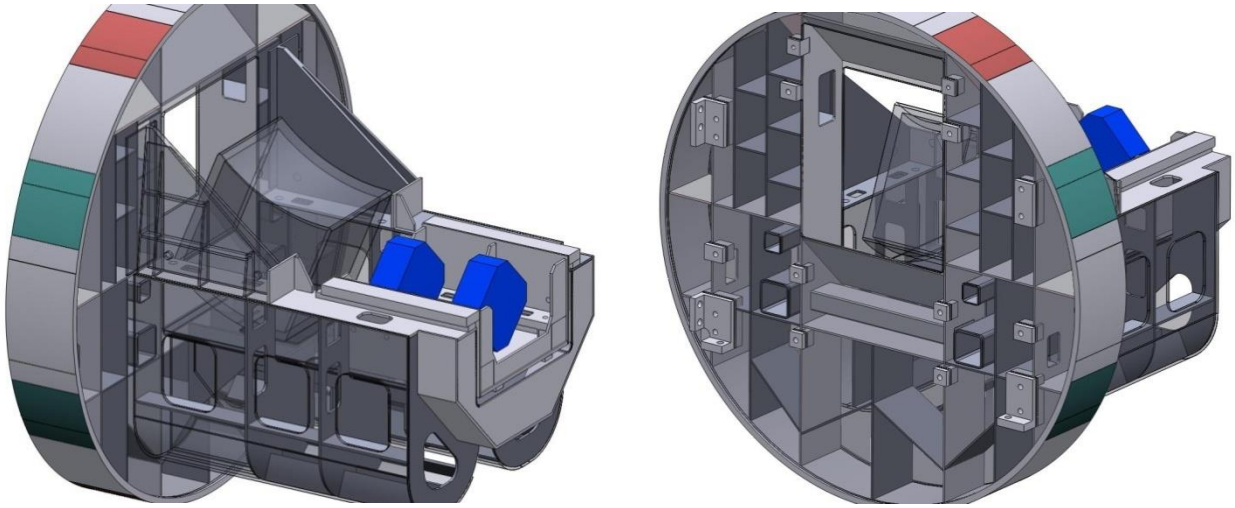
During the previous studies we could not get satisfying results regarding magnet displacement. After several iterations and design changes we have managed to get satisfactory results.



Old Design



New Design



Drum is reinforced with additional ribs

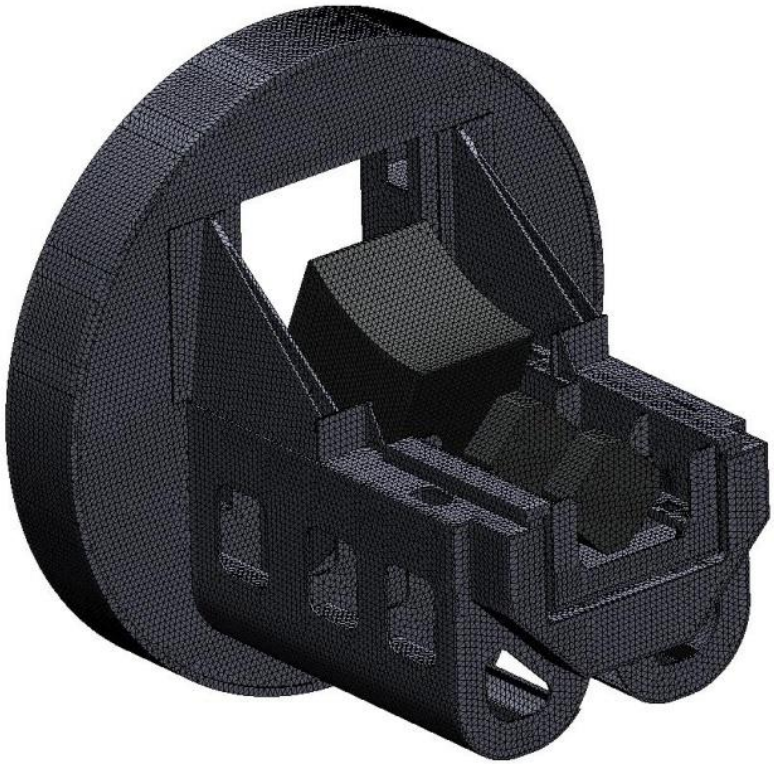
2.3. Material Properties

The same material was used for all components in the Cable Drum Assembly. The material properties are listed in following table:

Material Name:	**1.0037 (S235JR)**
Elastic modulus (N/mm^2)	2.1e+011
Poisson's ratio	0.28
Shear modulus (N/mm^2)	7.9e+010
Mass density (kg/m^3)	7800
Tensile strength (N/mm^2)	3.5e+008
Yield strength (N/mm^2)	2.75e+008
Thermal expansion coefficient (K)	1.1e-005
Thermal conductivity (W/mK)	14
Specific heat (J/kg.K)	440

3. 3D MODELING WITH FINITE ELEMENTS

Simplified 3D model of the Cable Drum Assembly was used as a basis for a mash creation, because that is the best way for getting the most accurate results regarding magnets displacement.



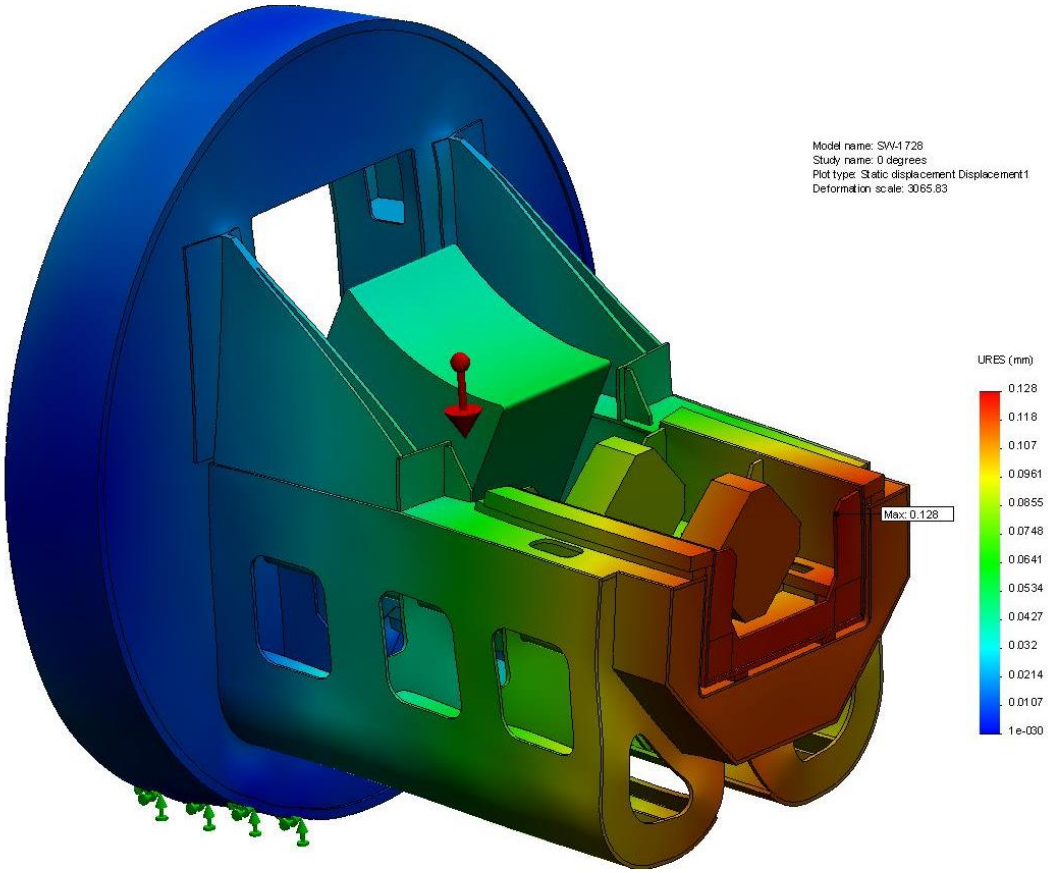
Mashed 3D model

The mash information is listed in following table:

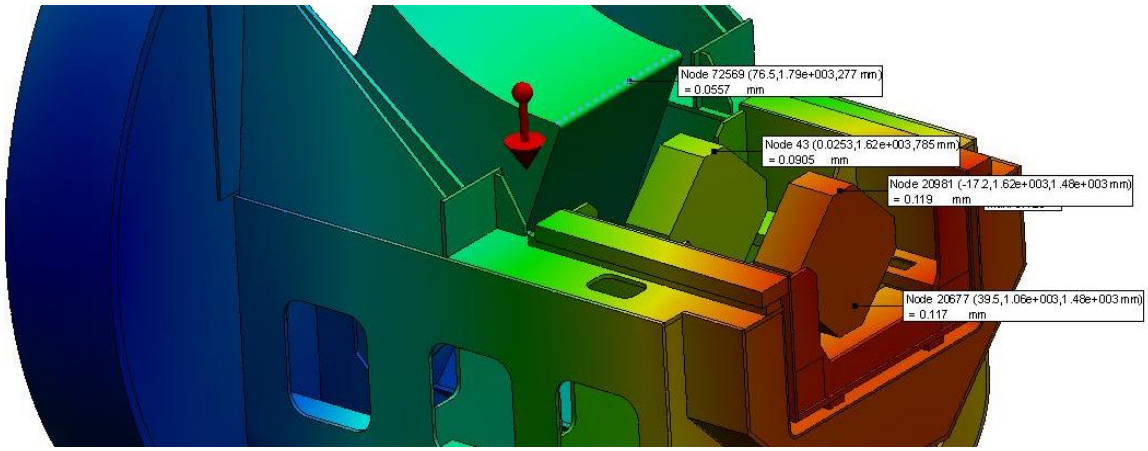
Mesh Type:	Solid Mesh
Mesher Used:	Standard mesh
Jacobian Check:	4 Points
Element Size:	50 mm
Tolerance:	1.5 mm
Quality:	High
Number of elements:	222873
Number of nodes:	445798

4. DISPLACEMENT AND STRESS ANALYSIS

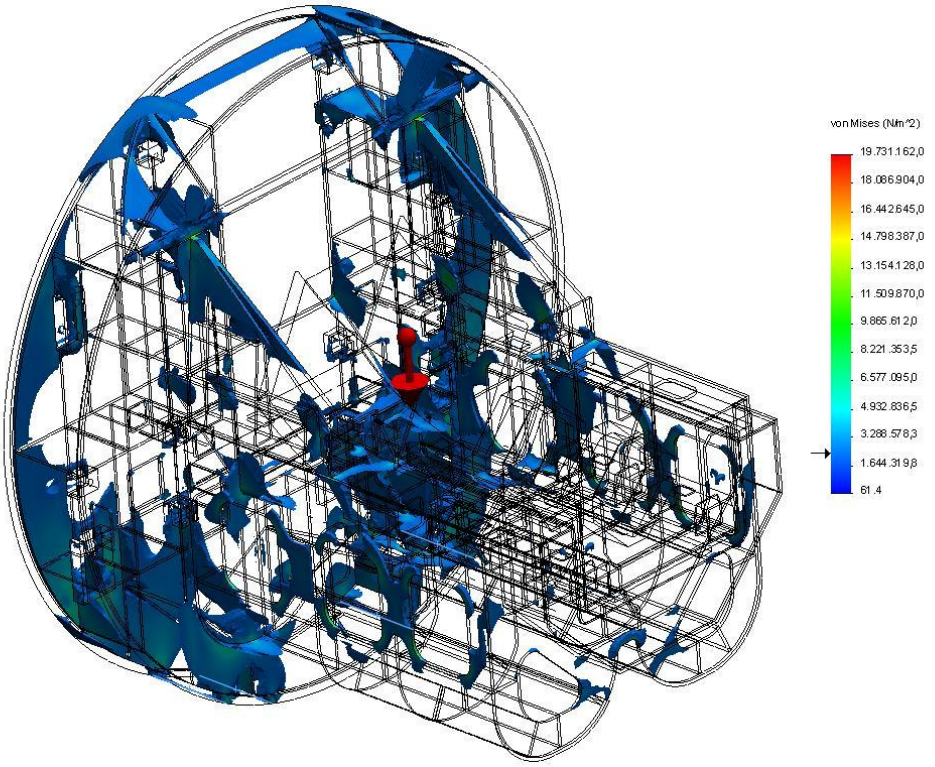
4.1. ANALYSIS OF 0 DEGREES POSITION



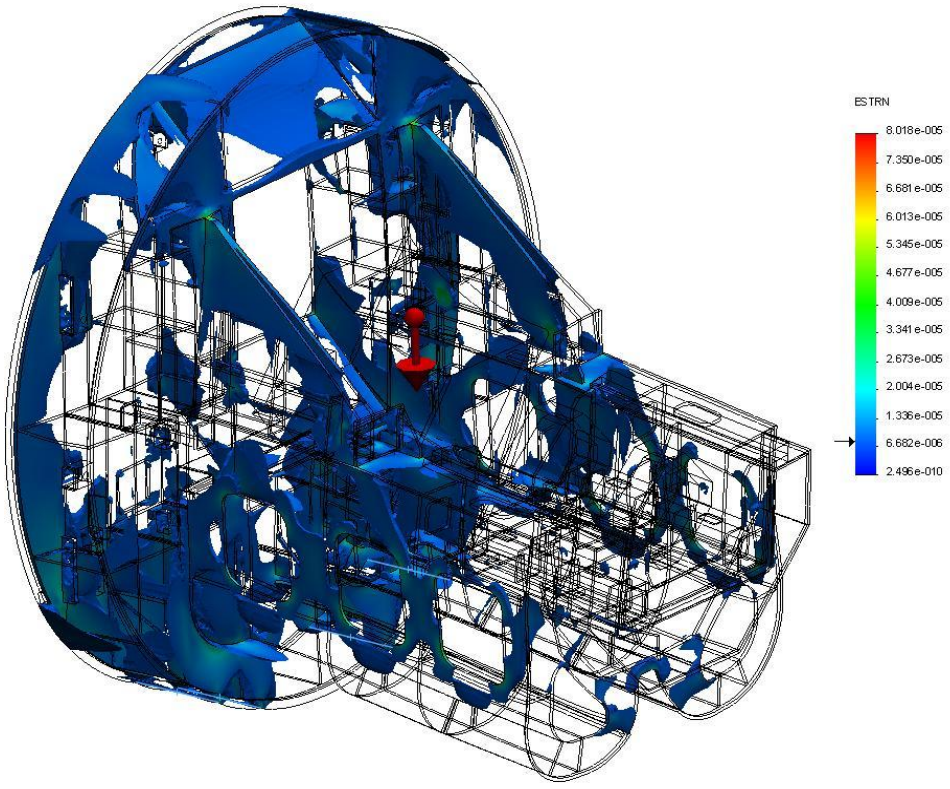
0 degrees displacement



0 degrees magnet displacement (Maximum magnet displacement is 0.119 mm < 0.3mm)

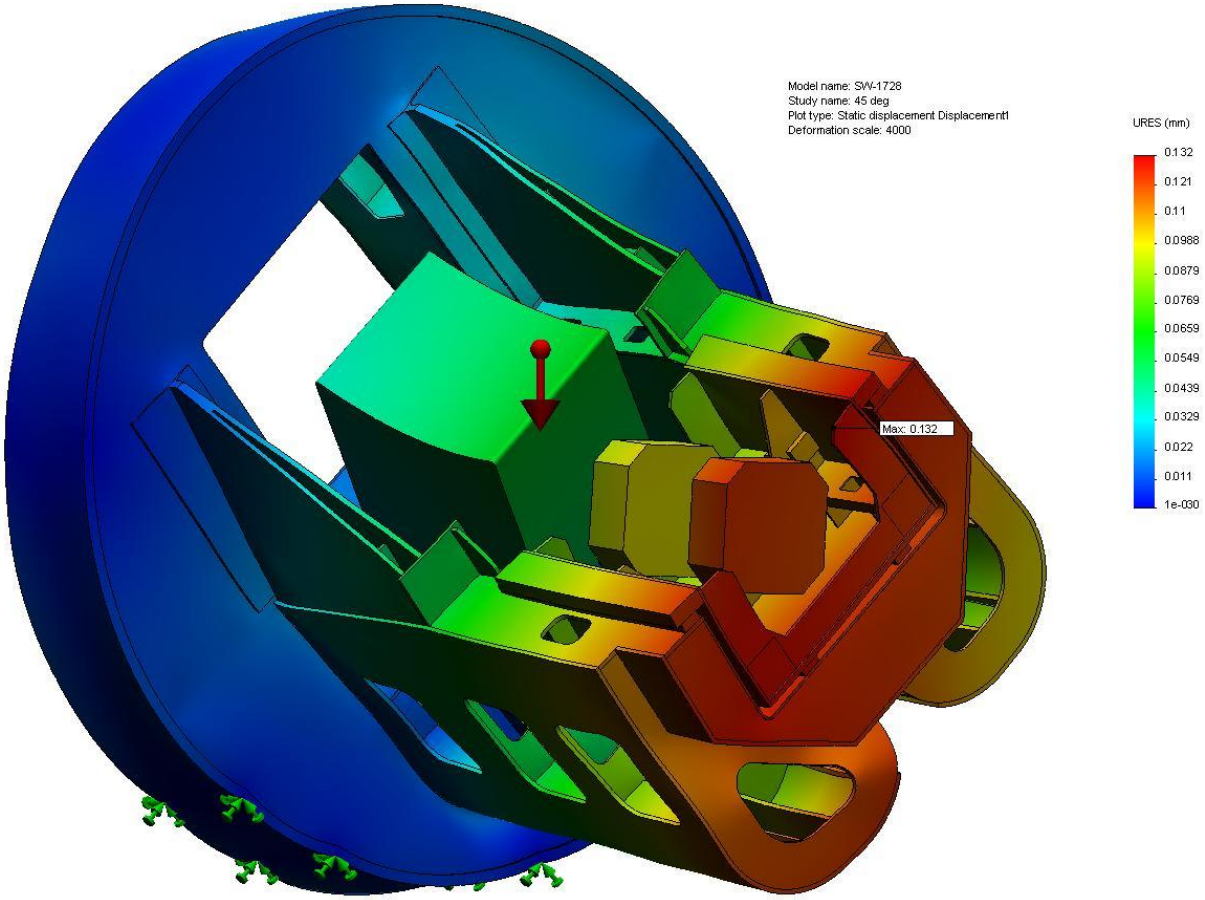


0 degrees – Stress

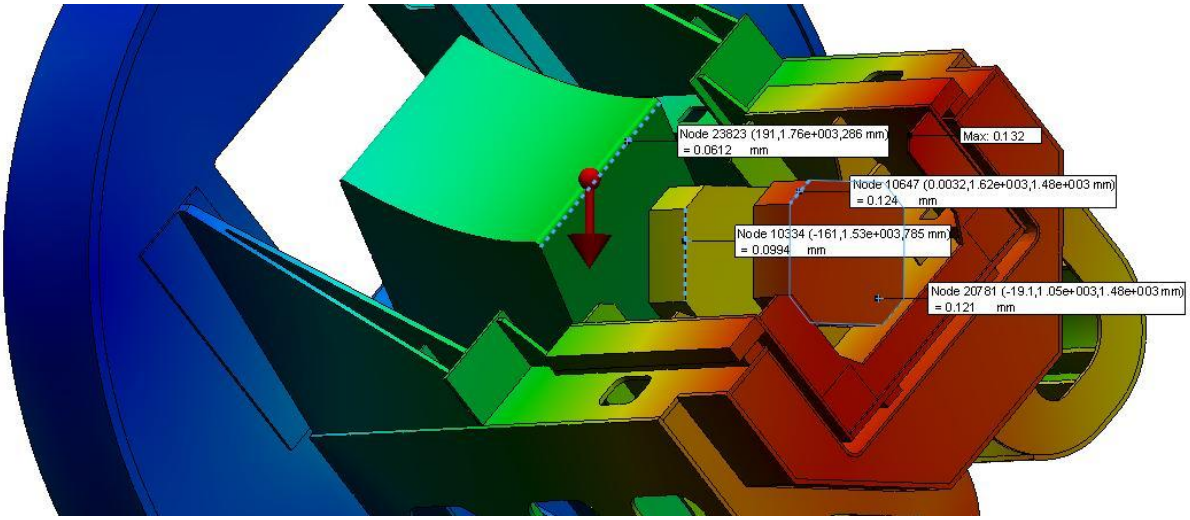


0 degrees - Strain

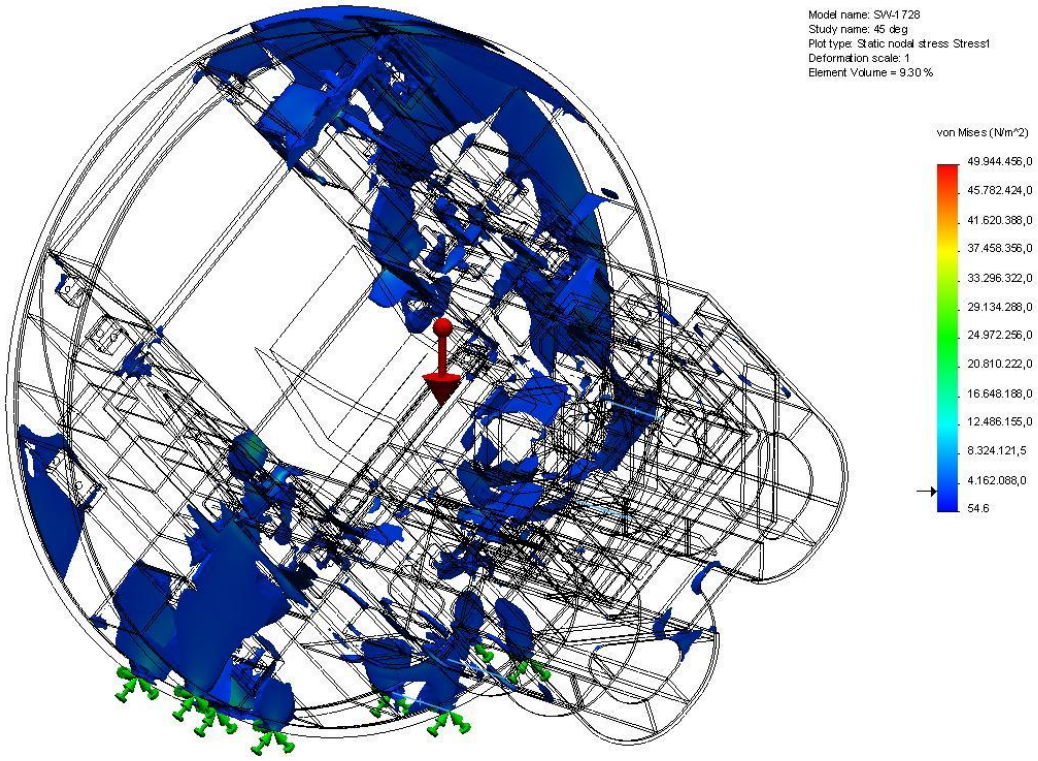
4.2. ANALYSIS OF 45 DEGREES POSITION



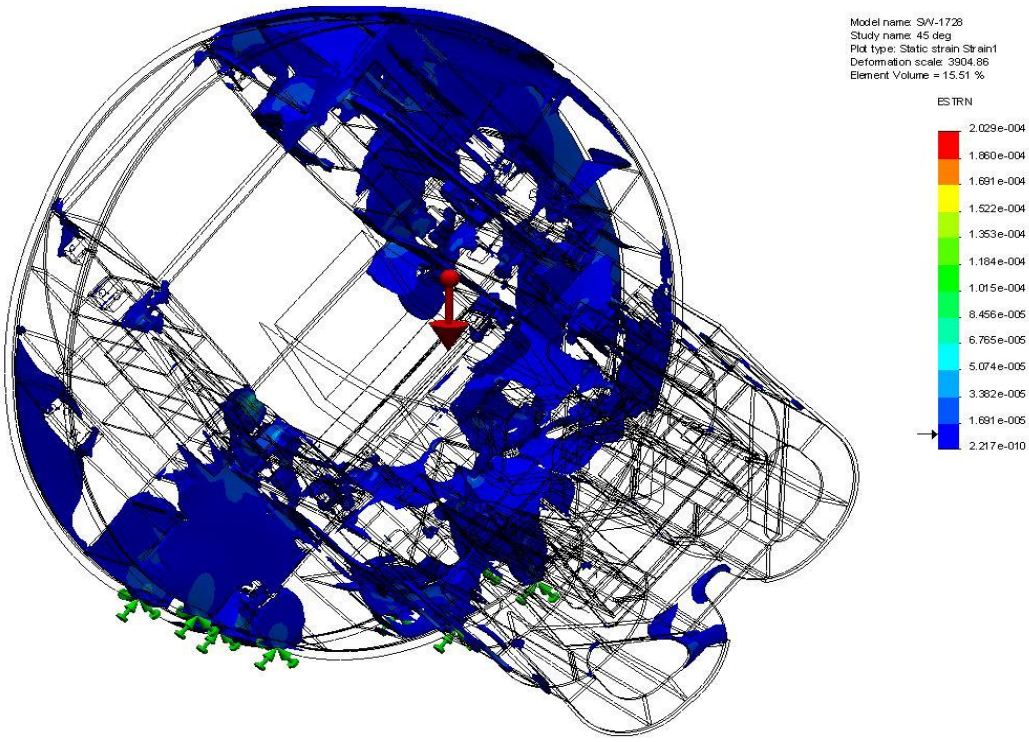
45 degrees displacement



45 degrees magnet displacement (Maximum magnet displacement is 0.124 mm < 0.3mm)

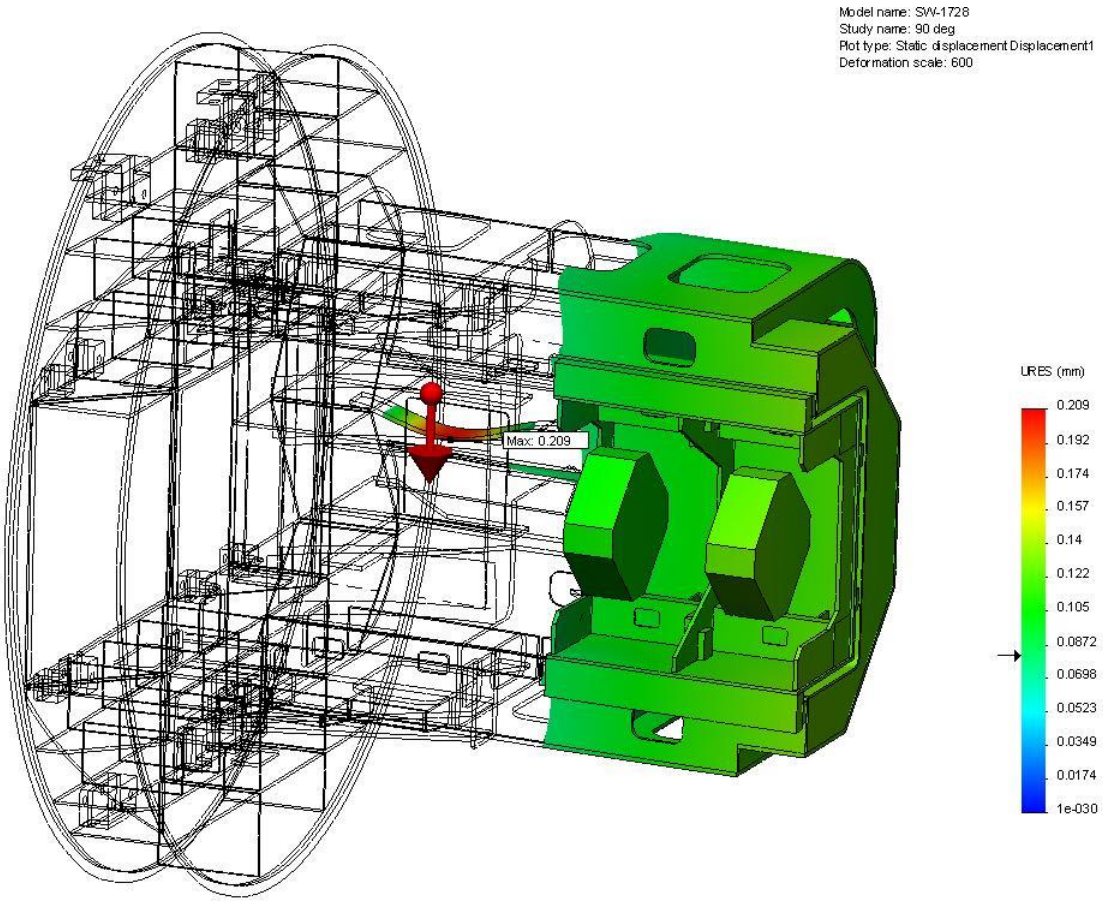


45 degrees - Stress

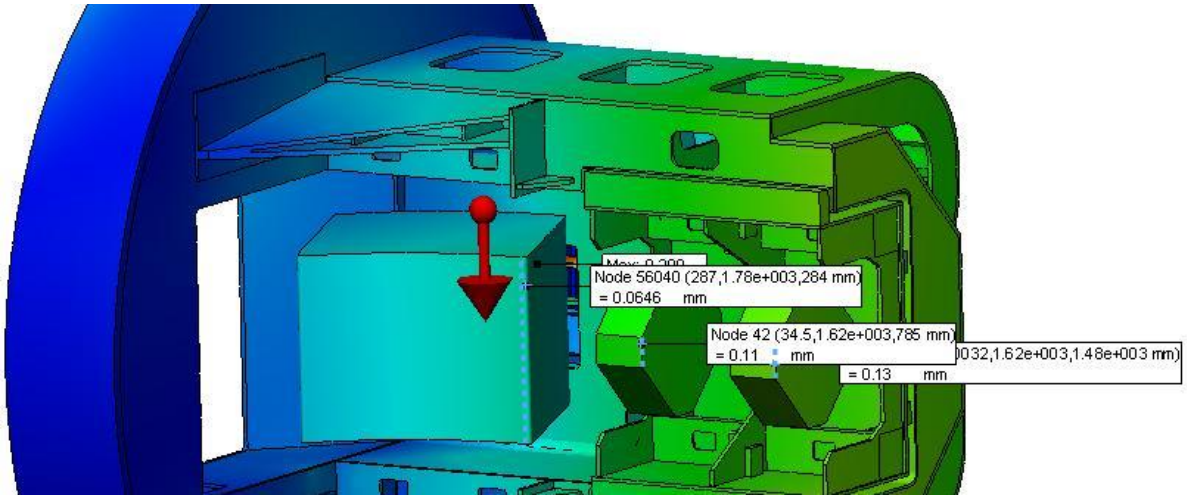


45 degrees - Strain

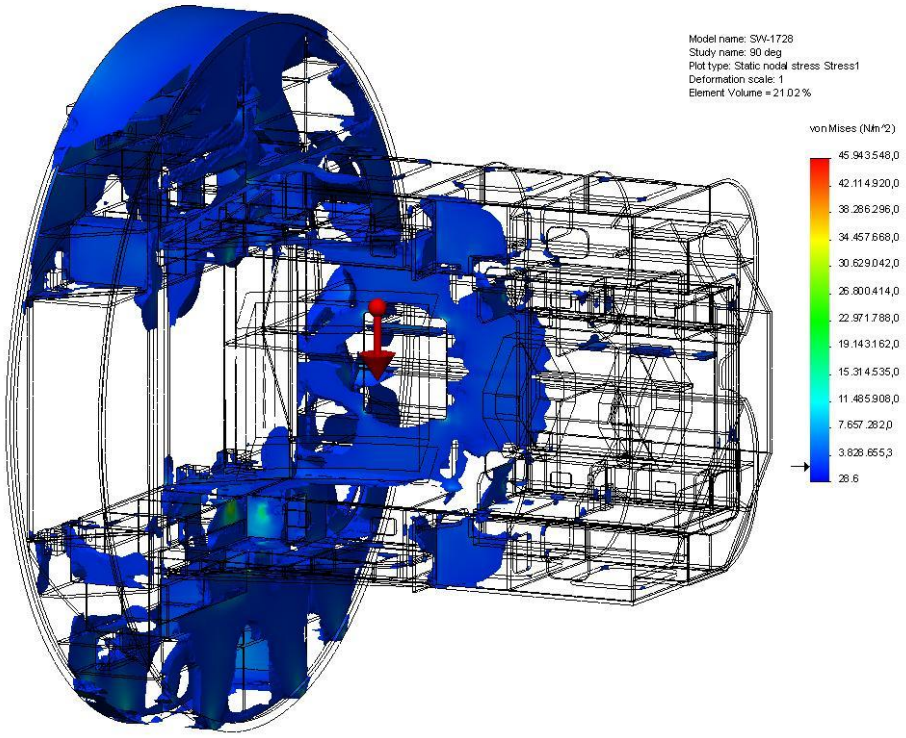
4.3. ANALYSIS OF 90 DEGREES POSITION



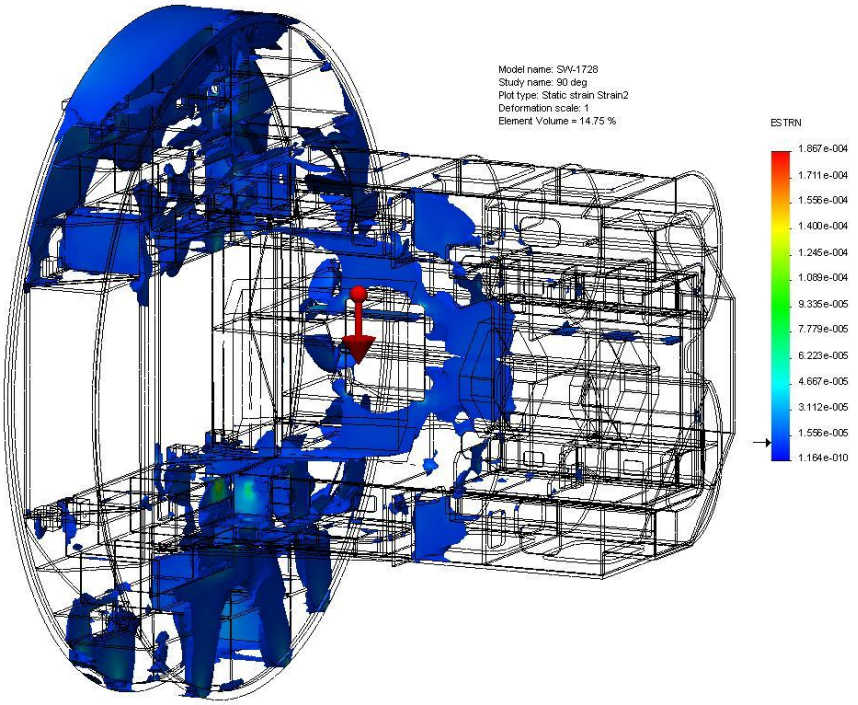
90 degrees displacement



90 degrees magnet displacement (Maximum magnet displacement is 0.13 mm < 0.3mm)

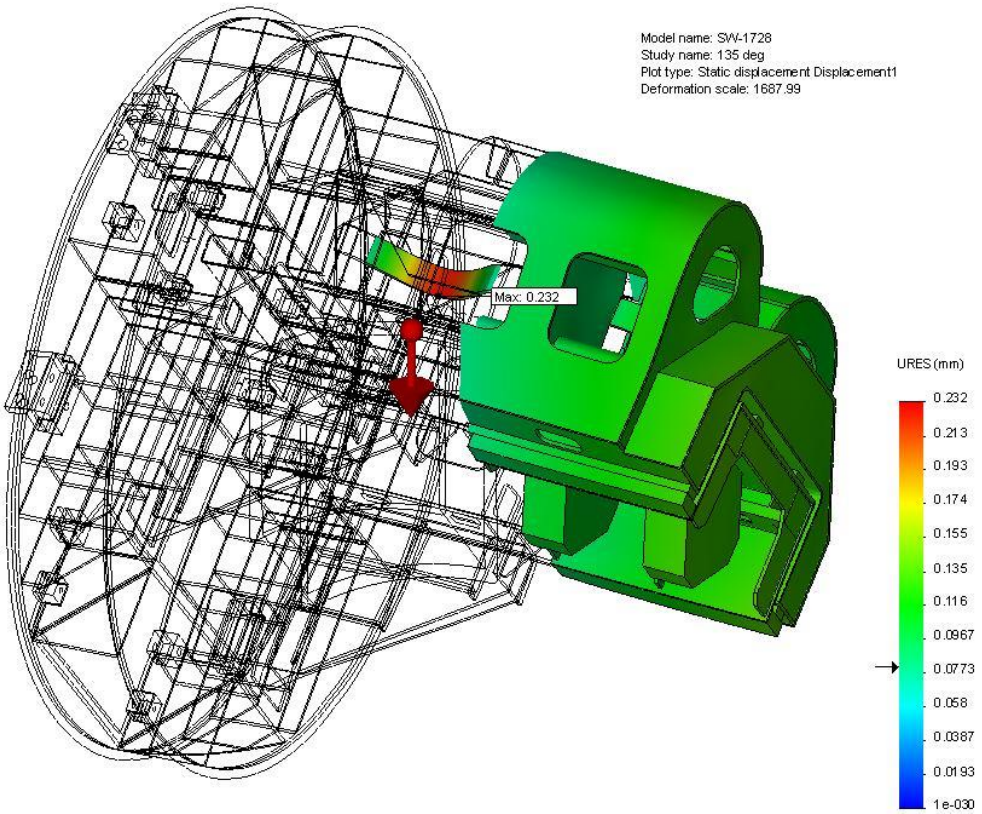


90 degrees – Stress

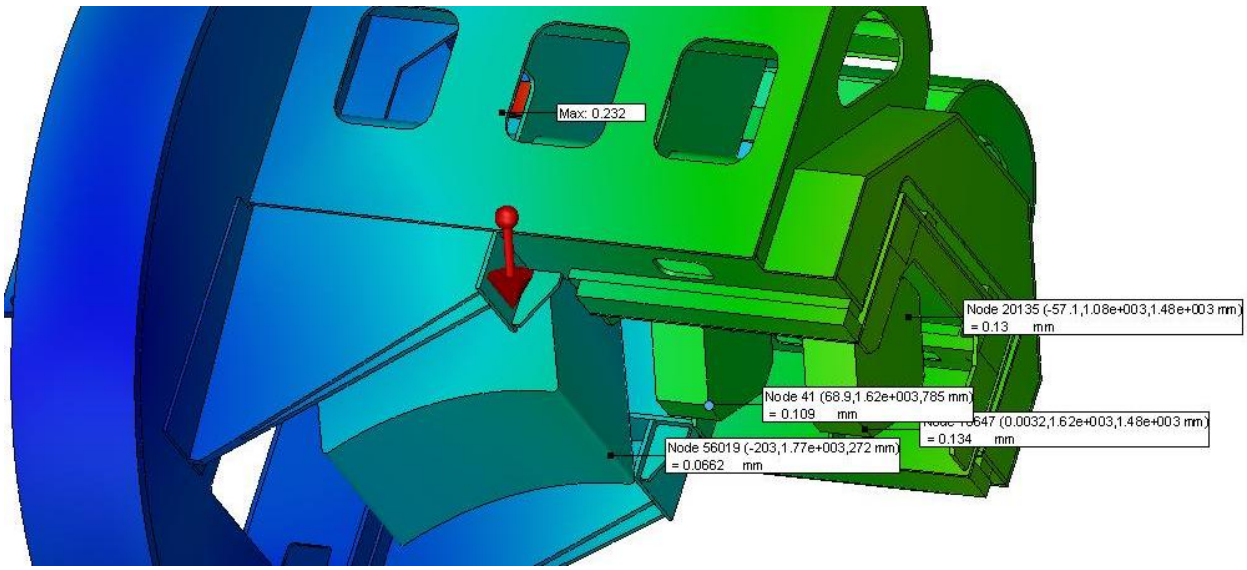


90 degrees – Strain

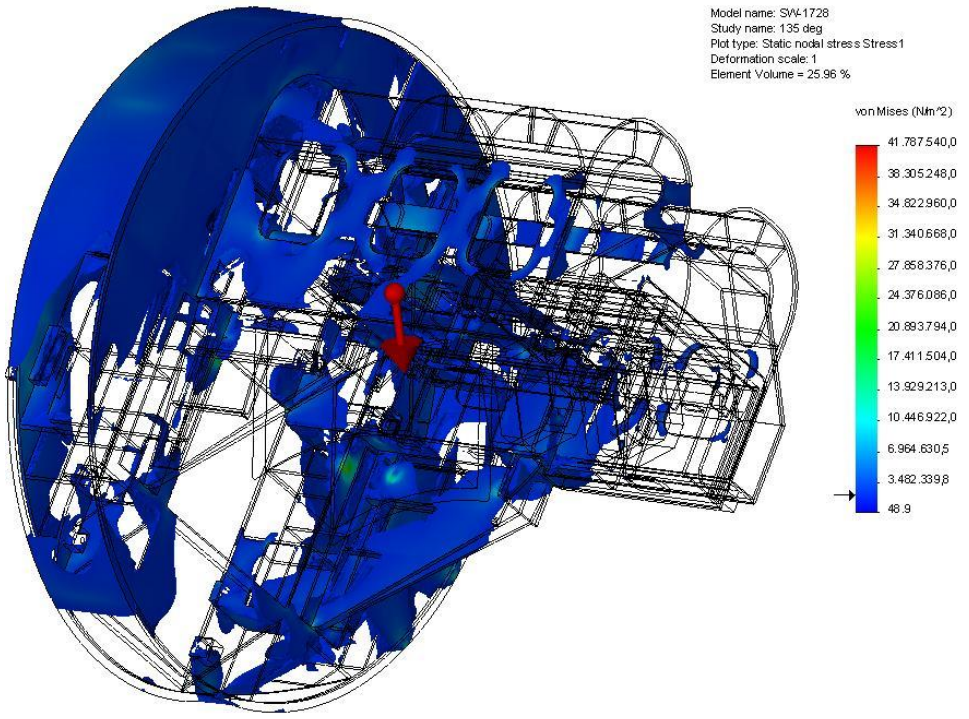
4.4. ANALYSIS OF 135 DEGREES POSITION



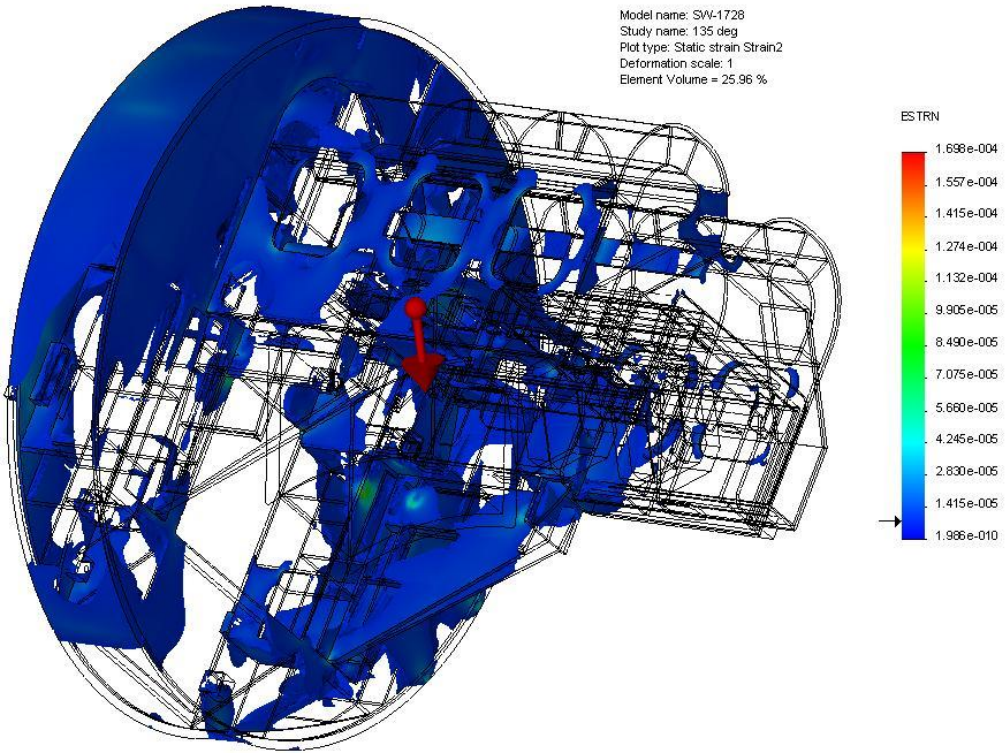
135 degrees displacement



135 degrees magnet displacement (Maximum magnet displacement is 0.134 mm < 0.3mm)

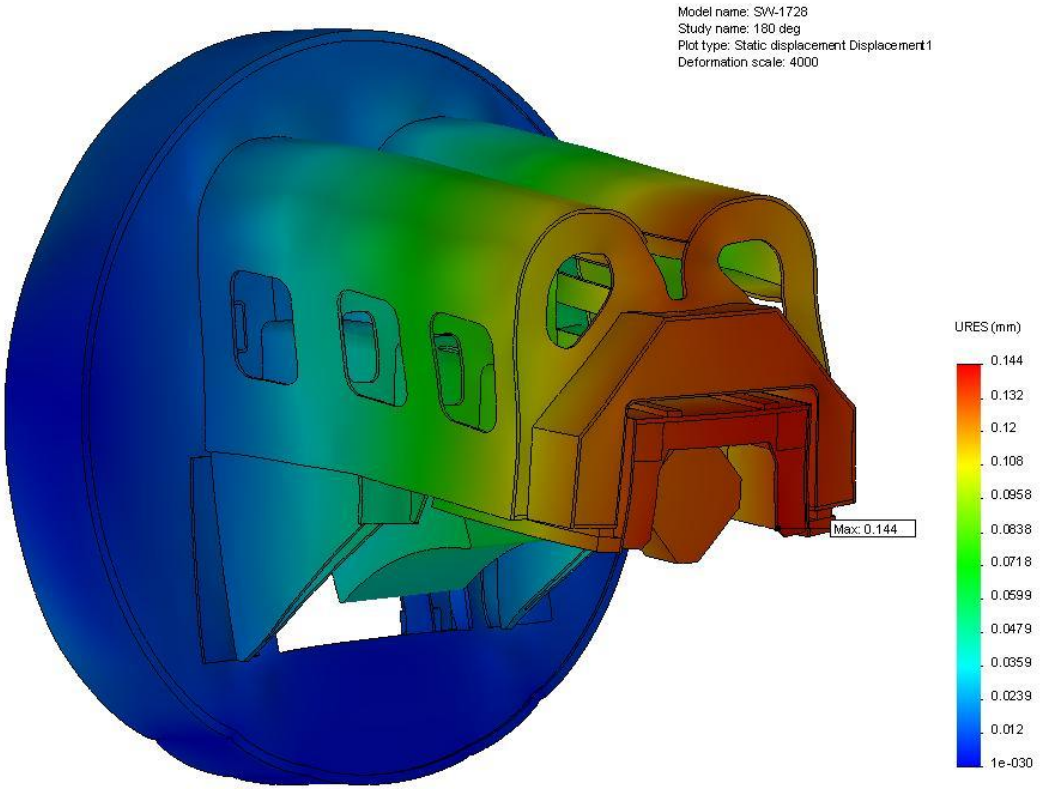


135 degrees – Stress

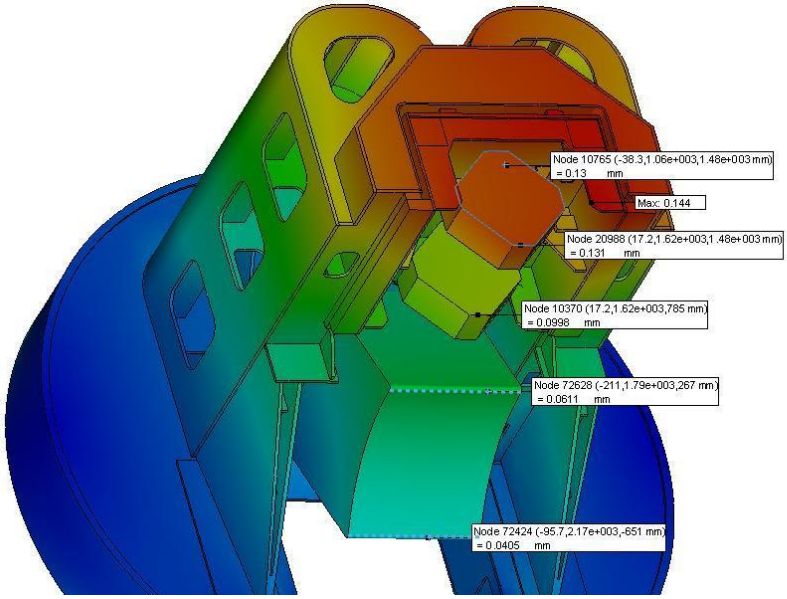


135 degrees – Strain

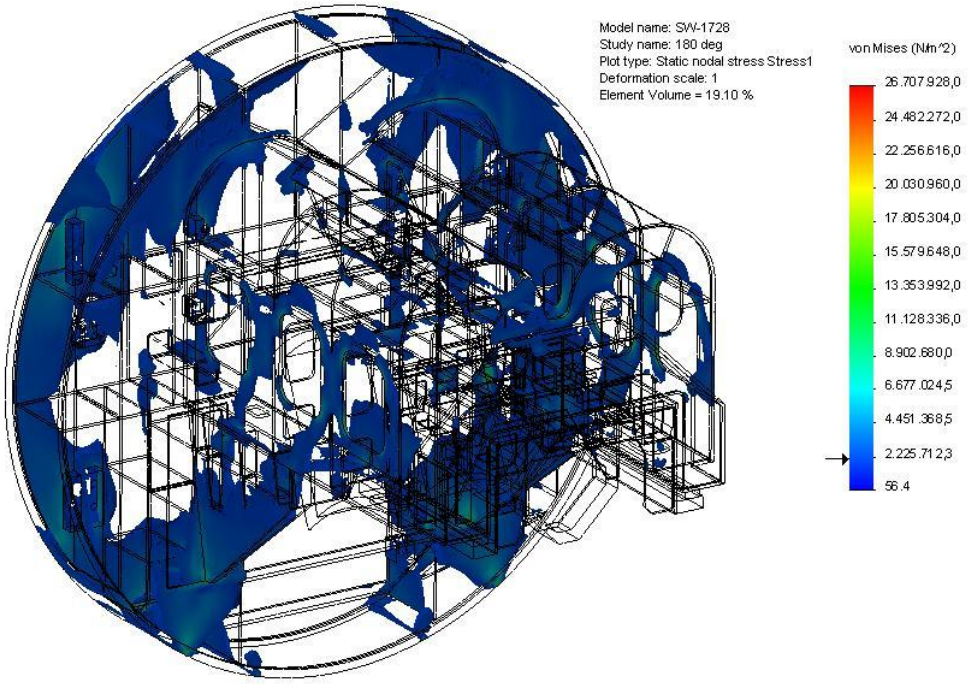
4.5. ANALYSIS OF 180 DEGREES POSITION



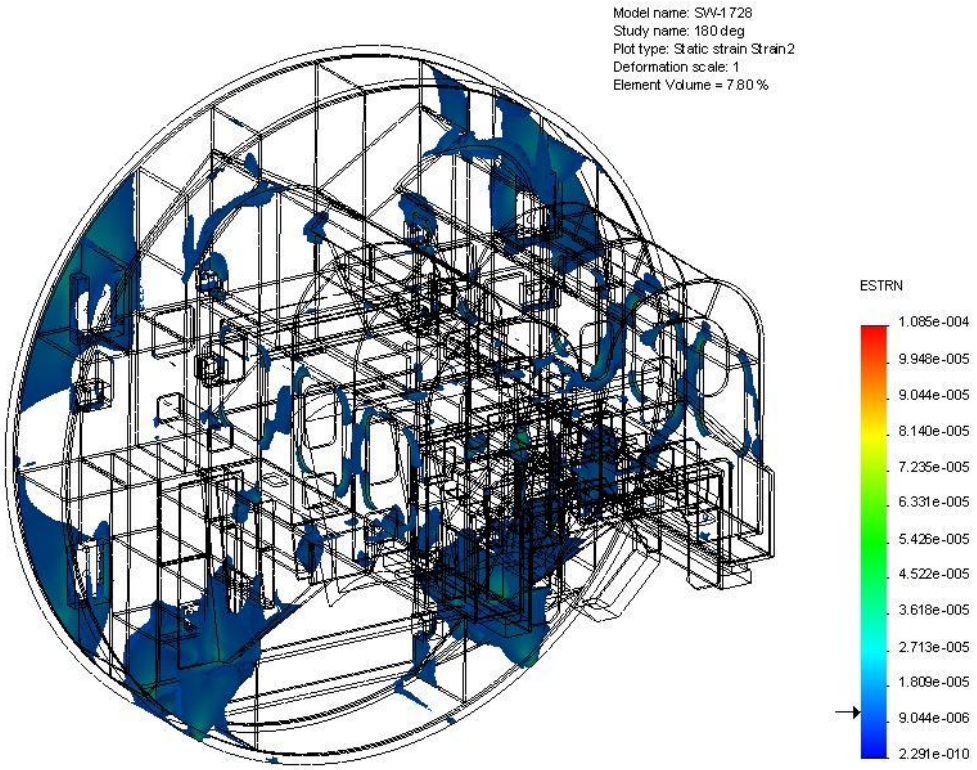
180 degrees displacement



180 degrees magnet displacement (Maximum magnet displacement is 0.131 mm < 0.3mm)



180 degrees – Stress



180 degrees – Strain

4.6. ANALYSIS OF -45, -90, -135, -180 DEGREES POSITIONS

Displacement and stress results for rotational positions of -45, -90, -135 and -180 degrees positions are approximately same with positions of 45, 90, 135 and 180 degrees, because they are symmetrical positions, so it is not necessary to consider them separately.

5. CONCLUSIONS

On the basis of the results obtained by means of the finite element method (FEM), the following conclusions can be made:

- Strain and stress results from pictures above were taken in consideration when we deciding where to put additional ribs and where to make design changes.
- Deformed results of displacements were also very important in making conclusions which areas of the Cable Drum should be stiffen to reduce deformations and consequently magnet displacement.
- Results shown in this report are obtained after several iterations and they are represent final results of FEM analysis and Cable Drum assembly which is applicable to satisfied basic requirement that maximal allowed magnets displacement should not be greater than 0.3mm.
- The maximal calculated magnet displacement is 0.134mm for the rotational position of 135 degrees. The calculated displacement is twice time lower from maximal allowed displacement of 0.3mm. In the following table will be summarized magnets displacement for all calculated rotational positions:

Rotational position (degrees)	Max. Displacement (mm)	Max. Allowed Displacement (mm)
0	0.119	0.3
45	0.124	
90	0.13	
135	0.134	
180	0.131	

- According to results shown in the previous table we can conclude that Cable Drum Assembly can fully satisfy operating and project requirements.